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$\beta$ Lyræ — Principal minimum, 1857, Feb. $6^d\ 1^h\ 54^{m}{\cdot}0$, G.M.T.
Period, $12^d\ 21^h\ 45^m\ 12^s$. First max. $3^d\ 2^h$; second min. $6^h\ 8^{h}{\cdot}5$,
and second max. $9^h\ 10^d$ after the minimum.
Its periods are slowly decreasing.

$\eta$ Aquilæ — Minimum, 1857, Feb. $6^d\ 14^h\ 3^{m}{\cdot}2$, G.M.T.
Period, $7^d\ 4^h\ 14^m\ 4^s$. Max. $2^d\ 9^h$ after the min.

$\delta$ Cephei — Minimum, 1857, Feb. $6^d\ 1^h\ 14^{m}{\cdot}3$, G.M.T.
Period, $5^d\ 8^h\ 47^m\ 40^{s}{\cdot}0$. Max. $1^d\ 14^{h}{\cdot}4$ after the min.

"It is much to be wished that observers in the southern hemisphere would attend to the observation of R *Hydræ*. This star is visible but for a very short time to us, especially if it is not observed in the morning, a time when the professional astronomer can seldom attend to it. Besides which, suitable stars of comparison at the maximum are wanting: $\psi$ and $\gamma$ *Hydræ* being so very different in brightness that the comparison can no longer be made with security when the variable is between the two, and thereby the time of maximum is very uncertain.

"Comparison-stars of intermediate brightness, which are only to be found in *Scorpio*, are too low on our horizon in Europe to be used with advantage. All these difficulties are absent to the southern observer. It is to these obstacles that we must attribute the circumstance that the elements of variability of a star so long known as this one has been are still almost wholly unknown. Its period is now manifestly shorter than it was 150 years ago, but the want of a continuous series of observations prevents our drawing any conclusions respecting its rate of diminution; and if our information is to be confined to observations procured in the northern hemisphere, it may, perhaps, happen that 150 years hence we may not know much more about it than at present."

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## *Supplement to the Solar Tables of Messrs. Hansen and Olufsen.* By P. A. Hansen.

(*Communicated by the Astronomer Royal.*)

In calculating the positions of the Sun for certain ancient eclipses, I have found that by means of the terms of the first and second order depending on the precession, of which Mr. Olufsen and I have taken account in our tables, we do not obtain the position of the Sun for times so distant from the epoch of the tables with all the precision which is desirable. I feel bound, accordingly, to add the terms of the third and fourth order, which have a sensible effect at those distant dates. By carrying farther

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the developments we find in the quantities designated by Z and W the following terms:—

In Z,

$$\left\{\begin{array}{llll} \;\;'' & +0''{\cdot}001979 & \sin(g''+\mathrm{X}t) + 0''{\cdot}000084 & \sin 2(g''+\mathrm{X}t) \\ -0{\cdot}000469 & +0{\cdot}007912 & \cos(g''+\mathrm{X}t) + 0{\cdot}000037 & \cos 2(g''+\mathrm{X}t) \end{array}\right\}\mathrm{T}^3$$

$$+\left\{\begin{array}{llll} & -0{\cdot}0000015 & \sin(g''+\mathrm{X}t) + 0{\cdot}0000015 & \sin 2(g''+\mathrm{X}t) \\ -0{\cdot}0000002 & -0{\cdot}0000009 & \cos(g''+\mathrm{X}t) - 0{\cdot}0000003 & \cos 2(g''+\mathrm{X}t) \end{array}\right\}\mathrm{T}^4$$

In W,

$$\left\{\begin{array}{llll} -0{\cdot}00074 & -0{\cdot}02081 & \cos(g''+\mathrm{X}t) - 0{\cdot}00122 & \cos 2(g''+\mathrm{X}t) \\ & +0{\cdot}08341 & \sin(g''+\mathrm{X}t) + 0{\cdot}00175 & \sin 2(g''+\mathrm{X}t) \end{array}\right\}\mathrm{T}^3$$

$$+\left\{\begin{array}{llll} -0{\cdot}000018 & +0{\cdot}000014 & \cos(g''+\mathrm{X}t) - 0{\cdot}000015 & \cos 2(g''+\mathrm{X}t) \\ & -0{\cdot}000011 & \sin(g''+\mathrm{X}t) - 0{\cdot}000005 & \sin 2(g''+\mathrm{X}t) \end{array}\right\}\mathrm{T}^4$$

where $$\mathrm{T} = \frac{t - 1850}{100}$$

In the Solar Tables we have not included the preceding terms, which, in point of fact, amount to a few seconds only for a thousand years before or after their epoch, considering such an approximation to be sufficient. But as some of the ancient eclipses reach back to more than 2500 before the epoch of the tables, and for this interval of time the terms involving $\mathrm{T}^3$ may amount to more than two minutes, we cannot neglect them when we wish to know exactly the results of the lunar tables for these eclipses.

I supply, then, on this occasion the necessary tables for these terms, with the addition of the coefficients of $\mathrm{T}^4$, although the latter amount to a few seconds only, even for 2500 years. The units adopted are the same as in the Solar Tables, namely, in the first table, the fifth decimal figure of Argument I., and in the second table the seventh decimal figure of the logarithm of the radius vector. As a unit of the fifth decimal figure of Arg. I. corresponds to $0''{\cdot}03$, and for eclipses we do not require seven decimals in the logarithm of the radius vector, the number of decimals employed in these tables will be sufficient. The numbers of these two tables are to be taken out with Arg. V. + Arg. XIII. of the Solar Tables + the day of the year.

As an example, I will calculate the position of the sun for the year −399, June $21^{\mathrm{d}}\ 6^{\mathrm{h}}$ Greenwich mean time, which is the time of the eclipse of Ennius, mentioned by Cicero.

In Paris mean time this date is,

$$= -400^{\mathrm{y}} + 1^{\mathrm{y}} + 172^{\mathrm{d}}{\cdot}25650$$
$$= -400^{\mathrm{y}} + 1^{\mathrm{y}}{\cdot}470$$

and with these dates we find from the Solar Tables the following values of the Arguments, to which the day of the year has been added, where required,—

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Arg. I = 169·83726 Arg. V + XIII = 188·320 Arg. X = 36·47
— II = 1369 — VI = 37·49 — XI + XIII = 5364
— III = 37 — VII = 32·93 — XII + XIII = 454
— IV = 32 — VIII = 58·39 — XIII = 197·900
— IX = 7·9 — XIV = 206·39

From Tables IX. and X, of the Solar Tables, and from the first of the tables below we deduce the numbers,

117·171 ; — 5·40 ; — 0·238 ; + 0·00002 ;

which must be multiplied by

$$-22{\cdot}49\ ;\ (-22{\cdot}49)^2\ ;\ (-22{\cdot}49)^3\ ;\ (-22{\cdot}49)^4\ ;$$

which gives,

— 263518
— 2731
+ 2707
+ 5
Sum = — 263537

and from the other tables of the inequalities of Arg. I. we find the sum of the inequalities = 160; consequently

Arg. I + its inequalities = 167·21790

by means of which Table XXXIV. gives

The apparent tropical longitude = 83° 45′ 49″·9

Next, from Tables XX. and XXI. of the Solar Tables, and from the second table below, we get the numbers

— 0·421 ; + 1·11 ; + 0·014 ; — 0·00005 ;

which must be multiplied by the same numbers which we have just mentioned; whence we have

+ 945
+ 561
— 159
— 13
Sum + 1334

And from the other tables we obtain the sum of the other inequalities of the logarithm of the radius vector = 634. Now, as Table XXXV. gives 0·0068721 for the principal term of this logarithm we shall have, by the addition of the inequalities which we have just calculated,—

Log. radius vector = 0·0070689.

We can verify this result by computing directly the sidereal longitudes and the logarithm of the radius vector, and then adding

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the precession and aberration. As, from the beginning of the year 1800 to the beginning of the year 1850 there are 50 Julian years less by 0·5 days, and the difference of the calendar in this century is 12 days, we have for the epoch of the tables,

$$1850^{y} - 12^{d}\cdot 5.$$

In the next place, as year $-399$ is the first after the preceding bissextile, we must deduct $0^{d}\cdot 25$ from the given time, which consequently becomes

$$-399^{y} + 172^{d}\cdot 00650.$$

The difference between these two times is

$$-2249^{y} + 184^{d}\cdot 50650;$$

for which we must compute the sidereal movement. Now as the Solar Tables give for the Julian year this movement $=360^{\circ} - 22''\cdot 56009$, we find for the above interval of time

$$195^{\circ}\ 56'\ 42''\cdot 4;$$

by adding to which $c'' = -33'\ 46''\cdot 3$, we get

$$g'' = 195^{\circ}\ 22'\ 56''\cdot 1\ ;$$

and with this value of $g''$ we find the secular variations of the expressions for $n''\ t''$, and $w''$, given in the Solar Tables,

$$= +\ 0''\cdot 41114\ (t - 1850) - 0''\cdot 04390\ \left(\frac{t - 1850}{100}\right)^{2}$$

$$\text{and} = -\ 0\ \cdot 6726\ \ (t - 1850) - 1\ \cdot 684\ \ \left(\frac{t - 1850}{100}\right)^{2}$$

where $t - 1850 = -2248\cdot 5$. Computing these, we find the secular variations of $n''\ t'' = -15'\ 46''\cdot 7$; and as the sum of the constants added in the Solar Tables to the other inequalities of Arg. I. is $=1791$, the sum of the inequalities found above becomes $= -6''\cdot 7$, after conversion into seconds. By adding these two numbers to the value of $g''$, we have

$$n''\ t'' = 195^{\circ}\ 7'\ 2''\cdot 7;$$

and with this value we find the equation of the centre

$$= -\ 29'\ 28''\cdot 6.$$

Now, as the longitude of the perigee $= 280^{\circ}\ 21'\ 41''\cdot 0$, by adding these numbers to the value of $n''\ t''$, we find the sidereal longitude $= 114^{\circ}\ 59'\ 15''\cdot 1$.

Next, Tables XLI. and XLII. give the precession $= -31^{\circ}\ 13'\ 5''\cdot 5$, and Table XLV. gives the aberration $= 19''\cdot 9$; consequently the apparent tropical longitude $= 83^{\circ}\ 45'\ 49''\cdot 7$, which differs from the longitude previously found by the table by only $0''\cdot 2$.

With the same value of $n''\ t''$ we find the principal term of the log. radius vector, less by the sum of the constants added to the tables of its inequalities, $=0\cdot 0069409$. After having performed

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the multiplications, the secular inequalities mentioned above become +661, and the other inequalities computed above were =634; whence

Log. radius vector = 0·0070704,

and the difference from the value found previously from the tables is 0·0000015, which is sufficient for our purpose.

## Table I.—*Inégalités de l'Arg. I. des Tables du Soleil.*

Arg. V. + Arg. XIII. + le Jour de l'Année.

| Arg. | Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^3$ | Diff. | Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^4$ | Arg. | Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^3$ | Diff. | Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^4$ |
|---|---|---|---|---|---|---|---|
| 0 | +0·209 | | −0·00004 | 192 | −0·240 | | +0·00003 |
| 8 | +0·216 | + 7 | −0·00004 | 200 | −0·241 | − 1 | +0·00004 |
| 16 | +0·219 | + 3 | −0·00003 | 208 | −0·238 | + 3 | +0·00006 |
| 24 | +0·217 | − 2 | −0·00002 | 216 | −0·231 | 7 | +0·00007 |
| 32 | +0·211 | 6 | −0·00002 | 224 | −0·220 | 11 | +0·00008 |
| 40 | +0·200 | 11 | −0·00001 | 232 | −0·205 | 15 | +0·00009 |
| 48 | +0·186 | 14 | −0·00001 | 240 | −0·186 | 19 | +0·00009 |
| 56 | +0·167 | 19 | −0·00001 | 248 | −0·164 | 22 | +0·00008 |
| 64 | +0·145 | 22 | −0·00001 | 256 | −0·140 | 24 | +0·00008 |
| 72 | +0·120 | 25 | −0·00002 | 264 | −0·113 | 27 | +0·00007 |
| 80 | +0·092 | 28 | −0·00003 | 272 | −0·085 | 28 | +0·00005 |
| 88 | +0·062 | 30 | −0·00003 | 280 | −0·055 | 30 | +0·00004 |
| 96 | +0·031 | 31 | −0·00004 | 288 | −0·024 | 31 | +0·00002 |
| 104 | −0·001 | 32 | −0·00005 | 296 | +0·007 | 31 | +0·00001 |
| 112 | −0·033 | 32 | −0·00006 | 304 | +0·038 | 31 | −0·00001 |
| 120 | −0·065 | 32 | −0·00007 | 312 | +0·068 | 30 | −0·00002 |
| 128 | −0·095 | 30 | −0·00007 | 320 | +0·097 | 29 | −0·00003 |
| 136 | −0·124 | 29 | −0·00007 | 328 | +0·124 | 27 | −0·00004 |
| 144 | −0·150 | 26 | −0·00006 | 336 | +0·148 | 24 | −0·00005 |
| 152 | −0·174 | 24 | −0·00005 | 344 | +0·169 | 21 | −0·00005 |
| 160 | −0·195 | 21 | −0·00004 | 352 | +0·187 | 18 | −0·00005 |
| 168 | −0·212 | 17 | −0·00002 | 360 | +0·201 | 14 | −0·00004 |
| 176 | −0·225 | 13 | −0·00001 | 368 | +0·212 | 11 | −0·00004 |
| 184 | −0·235 | 10 | +0·00001 | 376 | +0·218 | 6 | −0·00003 |
| 192 | −0·240 | − 5 | +0·00003 | 384 | +0·219 | + 1 | −0·00003 |